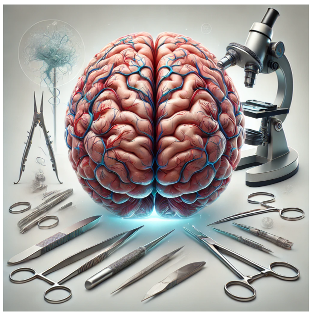


CNS—Anatomy~4
Written by: Dr.Ali Abujammil

Pain Control in the Central Nervous System - Descending Control of Pain

The central nervous system regulates pain perception through descending inhibitory pathways that reduce the transmission of pain signals. The main steps involved in this process are:

1. Spinoreticular fibers stimulate the Periaqueductal Gray (PAG): The PAG, located in the midbrain, plays a crucial role in pain modulation by receiving input from the spinal cord via the spinoreticular fibers.

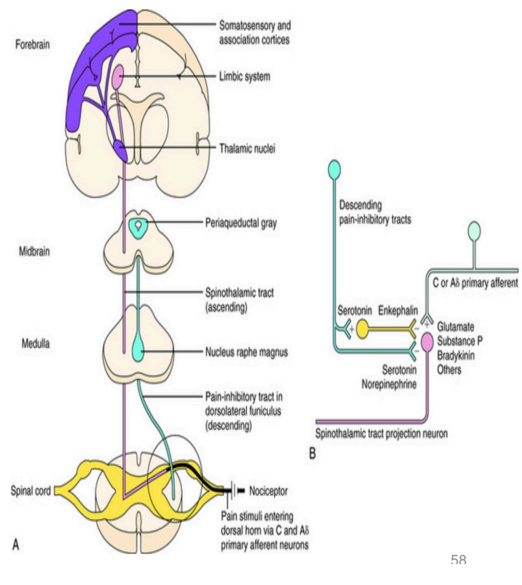
2. Excitatory neurons in the PAG project to the Nucleus Raphe Magnus (NRM): The NRM, found in the medulla oblongata, is responsible for modulating pain responses through the release of serotonin (5-HT).

3. NRM neurons release serotonin, which activates inhibitory neurons in the Substantia Gelatinosa: The Substantia Gelatinosa, located in the dorsal horn of the spinal cord, contains inhibitory interneurons that regulate pain signal transmission, These inhibitory neurons release enkephalins and endorphins, which act similarly to morphine by reducing pain perception. They achieve this by inhibiting the transmission of pain signals from Aß and C fibers.

4. The Locus Coeruleus (located in the Pons) is thought to directly inhibit neurons in the Substantia Gelatinosa, The Locus Coeruleus is a major source of norepinephrine, which contributes to pain inhibition by modulating activity in the substantia gelatinosa.

Pain signals are regulated through a descending pathway that begins in the PAG, continues to the NRM, and ultimately inhibits pain transmission in the substantia gelatinosa. This is achieved through the release of serotonin, which activates inhibitory neurons that secrete enkephalins and endorphins, effectively reducing pain perception. Additionally, the Locus Coeruleus enhances this inhibitory effect through norepinephrine release.

The image is a diagram illustrating the pain control mechanism in the central nervous system, focusing specifically on the descending pain control pathway. The diagram begins with pain signals (via nociceptors) reaching the spinal cord. These signals then ascend via the spinothalamic tract to various brain regions, including the nucleus raphe magnus (NRM) and the periaqueductal gray (PAG); Spinoreticular fibers stimulate the PAG, which in turn sends excitatory



signals to the NRM. NRM neurons produce serotonin, which activates inhibitory neurons that secrete enkephalins and endorphins (morphine-like substances). These substances inhibit the activity of neurons in the substantia gelatinosa of the spinal cord, reducing the sensation of pain,The diagram also shows the role of the locus coeruleus in the pons, which is thought to directly inhibit substantia gelatinosa neurons. The diagram further illustrates the various neural pathways involved in pain processing, including the somatosensory pathways, somatosensory cortex, and limbic system. The diagram clearly shows the ascending and descending pathways involved in pain modulation.

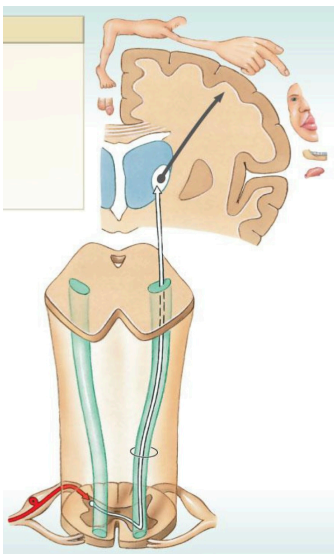
Anterior Spinothalamic Tract

Modality: Responsible for transmitting crude touch and pressure, which are non-discriminative tactile sensations that do not provide precise localization.

Receptors: Free nerve endings, which detect crude touch and pressure stimuli and relay them to sensory neurons.

Neural Pathway: 1st Neuron Dorsal Root Ganglion (DRG) contains the cell bodies of primary sensory neurons that receive input from peripheral receptors and send it to the spinal cord then 2nd Neuron Posterior Gray Column (Nucleus Proprius) Located in the dorsal horn of the spinal cord, where first-order neurons synapse with second-order neurons; The axons of second-order neurons cross to the opposite side of the spinal cord via the anterior gray and white commissures, After crossing, these axons ascend in the contralateral white column as the Anterior Spinothalamic Tract then 3rd Neuron Thalamus (VPL - Ventral Posterolateral Nucleus) processes somatosensory information and relays it to the cerebral cortex, From the thalamus, signals travel through the Internal Capsule and then via the Corona Radiata to reach the somatosensory cortex finally,The Primary Somesthetic Area (S1) in the Postcentral Gyrus of the Parietal Lobe is the final destination, where crude touch and pressure sensations are processed and interpreted.

The image depicts a diagram of a neural pathway called the Anterior Spinothalamic Tract. This tract is responsible for transmitting sensory information, specifically crude touch and pressure, from the body to the brain.



Modality: The tract carries information about crude touch and pressure. It doesn't convey fine details like discriminative touch or vibration and Receptors: The nerve signal originates in free nerve endings in the skin and other tissues.

1st Neuron: The cell bodies of the first-order neurons are located in the dorsal root ganglia of the spinal cord.

2nd Neuron: The cell bodies of the second-order neurons are located in the posterior gray column, specifically in an area called the nucleus proprius. The axons of the second-order neurons

decussate (cross) to the opposite side of the spinal cord via the anterior and white commissures before ascending.

3rd Neuron: The cell bodies of the third-order neurons are located in the ventral posterolateral nucleus (VPL) of the thalamus, After the thalamus, the nerve fibers pass through the internal capsule and then the corona radiata.

Termination: The nerve fibers terminate in the primary somesthetic area (SI) of the cerebral cortex, where the sensory information is processed.

The diagram visually shows the pathway's course from the spinal cord to the brain, highlighting the key anatomical structures involved.

Spinotectal Tract

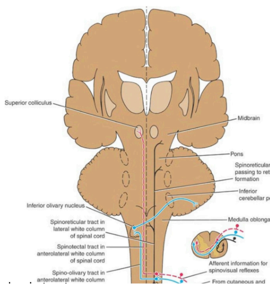
Pathway and Function: Ascends in the anterolateral white column, located near the lateral spinothalamic tract and Terminates in the superior colliculus of the midbrain.

Main Function: Carries afferent sensory information for spinovisual reflexes, which are rapid motor responses to visual stimuli, such as turning the head or eyes toward a source of light or movement.

In the Medulla Oblongata, It combines with two other tracts to form the Spinal Lemniscus: Spinotectal Tract, Lateral Spinothalamic Tract and Anterior Spinothalamic Tract.

Summary:The spinotectal tract is involved in visual reflexes by transmitting sensory information to the superior colliculus, and it contributes to the spinal lemniscus, which carries sensory signals to higher brain centers.

The image is a diagram illustrating the Spinotectal Tract in the central nervous system. This tract transmits sensory information from the body to the superior colliculus in the midbrain, Key points depicted in the diagram:



Tract Pathway: The spinotectal tract ascends in the anterolateral white column of the spinal cord, close to the lateral spinothalamic tract.

Termination Point: It terminates in the superior colliculus.

Function: It provides afferent spinovisual information for visual reflexes.

In the Medulla: The anterior spinothalamic tract, spinotectal tract, and lateral spinothalamic tract combine to form the spinal leminiscus.

The diagram also shows other brain structures such as the pons, midbrain, interior olivary nucleus, and spinoreticular tract. These areas are interconnected and involved in processing sensory information.

Posterior Spinocerebellar Tract

Main Function: Transmits muscle and joint sensation to the cerebellum, playing a crucial role in coordination and balance.

Neural Pathway:

1. 1st Order Neuron-Dorsal Root Ganglion (DRG): Carries deep proprioceptive sensations from muscles and joints to the spinal cord and Axons terminate in the posterior gray column, specifically in Clarke Nucleus (Nucleus Dorsalis).

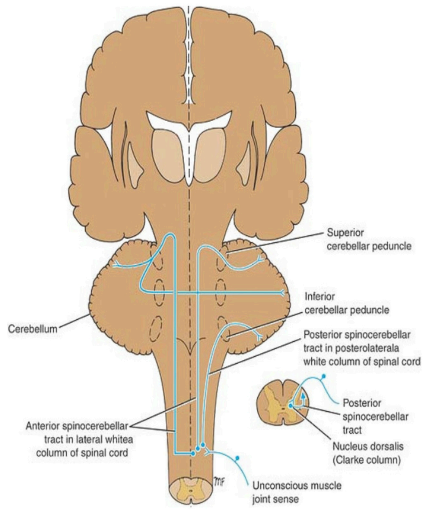
2. 2nd Order Neuron-Clarke Nucleus (T1 - L2/L3): Processes proprioceptive information and Axons enter the posterolateral part of the lateral white matter on the same side (Ipsilateral Side).

3. Ascending Pathway to the Cerebellum: The Posterior Spinocerebellar Tract ascends to the medulla oblongata, It then enters the Cerebellar Cortex via the Inferior Cerebellar Peduncle.

Important Note: Axons from lower lumbar and sacral spinal nerves first ascend in the posterior white column until they reach L3 or L4, where they synapse in Clarke Nucleus before joining the posterior spinocerebellar tract.

Summary: The Posterior Spinocerebellar Tract is essential for unconscious proprioception, providing the cerebellum with real-time information about muscle and joint position, ensuring smooth and coordinated movements and It remains ipsilateral, meaning it does not cross to the opposite side of the spinal cord.

The image depicts the pathway of the Posterior Spinocerebellar Tract. This tract is responsible for transmitting unconscious proprioceptive information from muscles and joints to the cerebellum, Key points illustrated in the diagram:



Muscle and Joint Sensation: The tract conveys sensory information about the state of muscles and joints; this information is not consciously perceived.

First-Order Neurons: Axons of first-order sensory neurons terminate at the base of the posterior gray column of the spinal cord, specifically in the nucleus dorsalis (Clarke's nucleus).

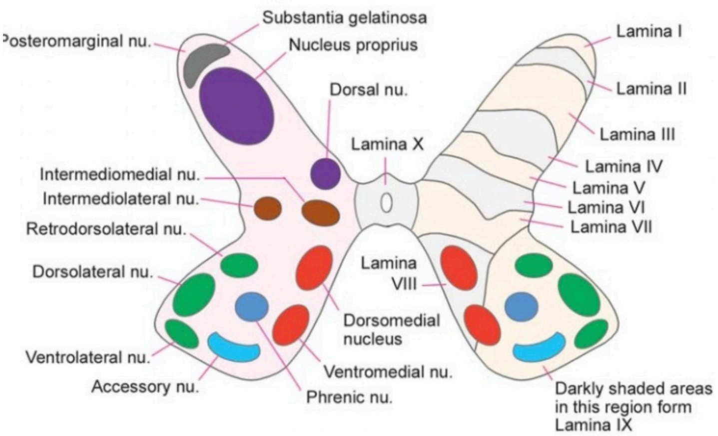
Second-Order Neurons: Axons of second-order neurons enter the posterolateral part of the white matter on the same side of the spinal cord.

Ascent to Cerebellum: These axons ascend as the posterior spinocerebellar tract to the medulla oblongata and then to the cerebellum via the inferior cerebellar peduncle.

Termination in Cerebellum: The tract terminates in the cerebellar cortex, where the unconscious proprioceptive information from muscles and joints is processed to help regulate movement and posture.

Special Note: Axons of lower lumbar and sacral spinal nerves ascend in the posterior white column until they reach L3 or L4 segments, where they synapse with the nucleus dorsalis.

The image shows a schematic diagram of Rexed laminae in the gray matter of the spinal cord. Rexed laminae are functional subdivisions of the gray matter, each with a specific role in processing sensory and motor information. The diagram illustrates the anatomical arrangement of these laminae, naming each lamina and its primary function, Explanation of the laminae:



ig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

Lamina I: Relays information related to pain and temperature.

Lamina II: Relays information related to pain and temperature and participates in pain modulation.

Laminae III & IV: Contain the nucleus proprius and many interneurons that connect different laminae.

Lamina V: Relays information related to pain and temperature.

Lamina VI: Present only in the cervical and lumbar enlargements of the spinal cord and receives proprioceptive information.

Lamina VII: Contains the intermediolateral nucleus (containing preganglionic sympathetic fibers), the intermediomedial nucleus (receiving visceral pain), and the nucleus of Clark (a relay center for unconscious proprioception).

Lamina VIII: Contains motor neurons and interneurons.

Lamina IX: Located in the ventral horn and contains lower motor neurons (LMN) subdivided into subnuclei:

Ventromedial nucleus: Controls abdominal and back muscles.

Dorsomedial nucleus: Controls intercostal and abdominal muscles.

Ventrolateral nucleus: Controls arm and thigh muscles.

Dorsolateral nucleus: Controls forearm and leg muscles.

Retrodorsolateral nucleus: Controls hand and foot muscles.

Central nucleus: Contains the phrenic nerve, which controls the diaphragm.

Lamina X: Surrounds the central canal of the spinal cord.

شرحت فيما سبق.

Anterior Spinocerebellar Tract

Main Function: Transmits muscle and joint sensation to the cerebellum, playing a crucial role in coordination and balance.

Neural Pathway:

1. 1st Order Neuron-Dorsal Root Ganglion (DRG): Carries proprioceptive sensations from muscles and joints to the spinal cord and Axons terminate in the posterior gray column, specifically in Clarke Nucleus.

2. 2nd Order Neuron-Clarke Nucleus (T1 - L2/L3): Sends axons along two different pathways:

1. The majority of fibers cross to the contralateral side via the anterior gray and white commissures, then ascend in the contralateral lateral white column as the Anterior Spinocerebellar Tract.

2. A minority of fibers remain ipsilateral and ascend in the same-side lateral white column as part of the same tract.

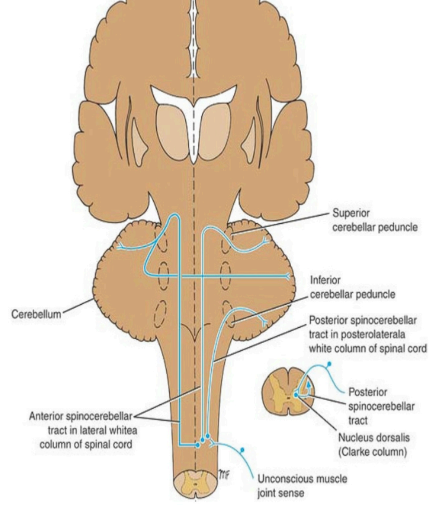
3. Ascending to the Cerebellum: The tract ascends through the medulla oblongata and pons, It enters the Cerebellar Cortex via the Superior Cerebellar Peduncle.

4. Double Crossing Within the Cerebellum: The fibers that crossed over in the spinal cord cross back within the cerebellum, ensuring that proprioceptive information reaches the ipsilateral cerebellar hemisphere, which controls movements on the same side of the body.

Summary: The Anterior Spinocerebellar Tract transmits proprioceptive information for unconscious motor coordination; It follows a double-crossing pathway, meaning that despite initially crossing in the spinal cord, it crosses back in the cerebellum, maintaining an ipsilateral functional organization, It enters the cerebellum via the Superior Cerebellar Peduncle.

The image presents a schematic diagram of the Anterior Spinocerebellar Tract (ASCT). This tract is responsible for conveying unconscious proprioceptive information from muscles and joints to the cerebellum. The illustration shows the pathway of this tract from the spinal cord to the cerebellum, Explanation of the diagram:

Muscle and Joint Sensation: The tract begins by



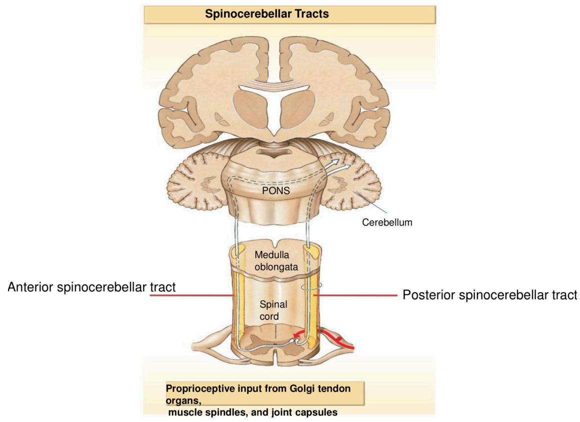
transmitting unconscious sensory information about the state of muscles and joints.

First-Order Neurons: Axons of first-order sensory neurons terminate at the base of the posterior gray column of the spinal cord, specifically in the nucleus dorsalis (Clarke's nucleus).

Second-Order Neurons: The majority of axons of second-order neurons cross to the opposite side of the spinal cord and ascend as the anterior spinocerebellar tract in the lateral white column. A small minority remain ipsilateral.

Ascent to Cerebellum: These axons ascend as the anterior spinocerebellar tract to the medulla oblongata and pons, and then to the cerebellum via the superior cerebellar peduncle.

Termination in Cerebellum: The tract terminates in the cerebellar cortex, where the unconscious proprioceptive information from muscles and joints is processed to help regulate movement and posture. Fibers that crossed over in the spinal cord cross back within the cerebellum.



The image displays a schematic diagram of the anterior and posterior spinocerebellar tracts. These tracts are responsible for transmitting unconscious proprioceptive information from the body to the cerebellum. Proprioception refers to the sense of body position and movement in space, which is not consciously perceived, Explanation of the diagram:

The Two Tracts: The diagram illustrates the pathways of both the anterior spinocerebellar tract (ASCT) and the posterior spinocerebellar tract (PSCT) from the spinal cord to the cerebellum. While conveying slightly different proprioceptive information, both contribute to the regulation of movement and balance.

Source of Information: The tracts receive sensory input from various sensory receptors in muscles and joints, such as Golgi tendon organs, muscle spindles, and joint capsules. These receptors sense muscle stretch, joint position, and tendon tension.

Tract Pathways: The image shows how the tracts ascend through the brainstem to the cerebellum. The ASCT crosses to the opposite side of the spinal cord and then back to the same side in the cerebellum, while the PSCT remains ipsilateral throughout its course.

The Cerebellum: The tracts terminate in the cerebellum, where the unconscious proprioceptive information is processed to help fine-tune movement, coordinate actions, and maintain balance.

Motor Tracts

Major Descending Pathways, There are two main types of motor tracts responsible for movement control:

1. Pyramidal Tracts (Corticospinal Tracts): Responsible for conscious control of skeletal muscles and Originate in the motor cortex and project to the spinal cord, where they synapse with lower motor neurons (LMNs) that innervate muscles, Includes: Lateral Corticospinal Tract Controls fine voluntary movements of the limbs and Anterior Corticospinal Tract Controls axial muscles (neck, trunk).

2. Extrapyramidal Tracts: Responsible for subconscious regulation of Balance, Muscle tone, Eye, hand, and upper limb positioning and Originate in the brainstem but are influenced by the cerebral cortex, Includes: Vestibulospinal Tract Maintains balance and posture by activating extensor muscles based on input from the vestibular system of the inner ear and Reticulospinal Tract Controls muscle tone and automatic movements, such as walking and posture adjustments and Rubrospinal Tract Facilitates upper limb movement, particularly fine motor control, by exciting flexor muscles and Tectospinal Tract Controls visual and auditory reflexes, such as turning the head and eyes toward a stimulus.

Motor Neurons:

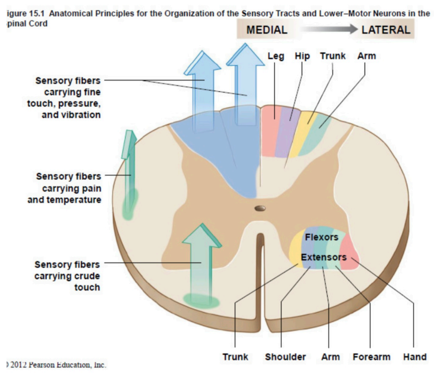
1. Upper Motor Neurons (UMNs): Located in the motor cortex or brainstem, sending signals to lower motor neurons in the spinal cord.

2. Lower Motor Neurons (LMNs): Located in the cranial nerve nuclei or anterior horn of the spinal cord, directly innervating skeletal muscles and causing movement.

Summary: Pyramidal Tracts control voluntary movements and Extrapyramidal Tracts regulate involuntary movements, balance, and muscle tone under cortical influence also Upper Motor Neurons regulate Lower Motor Neurons, which directly activate muscles.

The image shows a schematic diagram illustrating the anatomical principles for the organization of sensory tracts and lower motor neurons in the spinal cord. The diagram depicts the organization of motor neurons in the anterior horn of the spinal cord, as well as the organization of sensory fibers entering the spinal cord, Explanation of the diagram:

Motor Neurons: Located in the anterior horn of the spinal cord and are divided into two groups: Medial Group



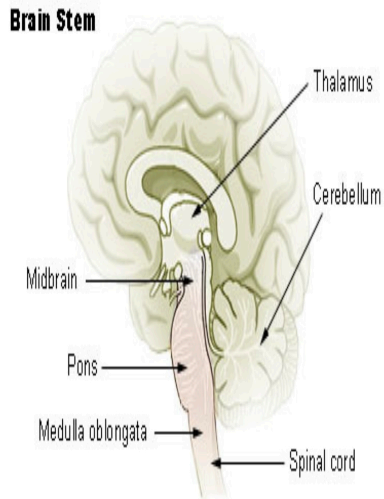
Present throughout the spinal cord and innervates trunk muscles and Lateral Group: Present only in the cervical and lumbar enlargements of the spinal cord and innervates limb muscles.

Sensory Fibers: Enter the spinal cord and transmit different sensory information like Fibers carrying fine touch, pressure, and vibration Enter medially and are somatotopically organized, Fibers carrying pain and temperature Enter laterally, Fibers carrying crude touch Enter laterally also.

Organization of Sensory Fibers: The diagram shows that sensory fibers carrying fine touch, pressure, and vibration are located medially in the spinal cord, while fibers carrying pain, temperature, and crude touch are located laterally. This somatotopic organization helps in efficient processing of sensory information.

Muscles: The diagram also shows the organization of muscles in the limbs, with flexors and extensors located in specific positions.

Brainstem



Definition and Function: Stalk-like structure at the base of the brain, Connects the spinal cord to higher brain centers in the forebrain, Regulates vital autonomic functions such as breathing, heart rate, and blood pressure also Contains sensory and motor pathways essential for body functions.

Parts of the Brainstem:

1. Medulla Oblongata: The lowest part of the brainstem, directly connected to the spinal cord, Controls vital functions like breathing, heart rate, and blood pressure, Contains the pyramidal decussation, where most motor fibers cross to the opposite side and Houses cranial nerve nuclei, including Vagus (CN X) and Hypoglossal (CN XII).

2. Pons: Located above the medulla, acting as a bridge between the cerebellum and the rest of the brain, Regulates breathing in coordination with the medulla and Contains cranial nerve nuclei, including Trigeminal (CN V) and Facial (CN VII).

3. Midbrain: Located above the pons, connecting the brainstem to the cerebrum, Contains the Corpora Quadrigemina, responsible for visual and auditory reflexes, Includes the Substantia Nigra, which regulates movement (degeneration is linked to Parkinson disease) and Houses the Oculomotor (CN III) and Trochlear (CN IV) nuclei, which control eye movements.

Summary: The brainstem is the main connection between the spinal cord and the brain, responsible for vital autonomic functions, motor control, and sensory processing, It consists of three parts: Medulla Oblongata Regulates breathing, heart rate, and blood pressure; Pons Acts as a bridge and assists in respiratory control and Midbrain Controls visual/auditory reflexes and movement coordination.

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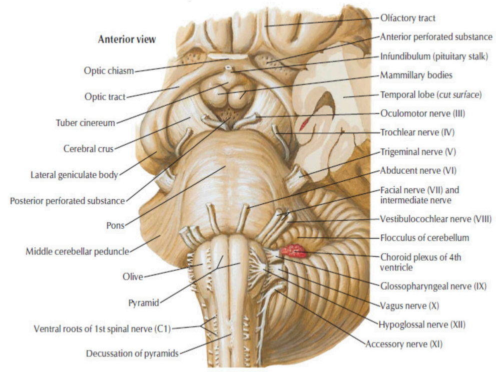


The image shows an anterior view of the brain, illustrating many of its major components and cranial nerves:

Optic chiasm: Where the optic nerves from each eye cross.

Optic tract: Nerves carrying visual information from the optic chiasm to the brain.

Tuber cinereum: A small area at the base of the brain.

Cerebral crus: Part of the midbrain.

Lateral geniculate body: A center for processing visual information.

Posterior perforated substance: An area in the brain with small holes.

Pons: Part of the brainstem.

Middle cerebellar peduncle: A bundle of nerve fibers connecting the cerebellum to the pons.

Olive: An oval-shaped structure in the medulla oblongata.

Pyramid: A structure in the medulla oblongata.

Ventral roots of 1st spinal nerve (C1): Nerve fibers carrying motor information from the spinal cord.

Decussation of pyramids: Where motor nerve fibers cross.

Olfactory tract: Carries olfactory information.

Anterior perforated substance: An area in the brain with small holes.

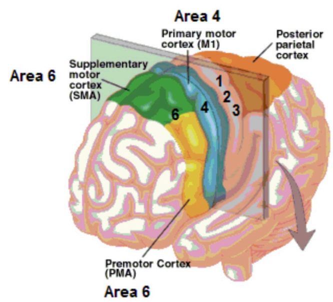
Infundibulum: Connects the hypothalamus to the pituitary gland.

Mammillary bodies: Important centers for memory.

Temporal lobe: Part of the cerebral cortex.

Cranial nerves: Nerves that emerge directly from the brain. The image shows several of them with their Roman numerals.

Origin of Motor Pathways, Both pyramidal and extrapyramidal tracts originate from the cerebral cortex, The main cortical areas involved are: Area 4 Primary Motor Cortex, Area 6 Premotor and Supplementary Motor Cortex also Area 312 Primary Somatosensory Cortex.



Pyramidal Tracts: Mainly originate from Area 4 (Primary Motor

Cortex), Responsible for voluntary fine motor control, particularly for limb and skeletal muscle movements.

Extrapyramidal Tracts: Mainly originate from Area 6 (Premotor and Supplementary Motor Cortex), Responsible for involuntary motor control, including muscle tone, balance, and coordination.

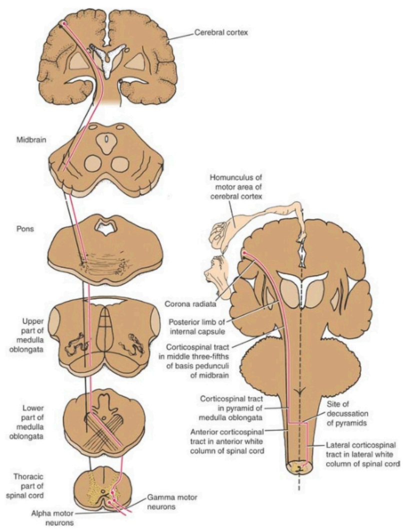
Functions of Area 6: Premotor Area Uses external cues to plan and execute movements, such as seeing an object and reaching for it and Supplementary Motor Area (SMA) Uses internal cues, enabling movement planning without external stimuli, like moving a hand voluntarily without seeing a trigger.

Lateral Corticospinal Tract (LCST)

Origin and Pathway: Upper Motor Neurons (UMNs) originate in the Precentral Gyrus of the primary motor cortex, In the Midbrain Pass through the middle three-fifths of the Basis Pedunculi; In the Medulla Oblongata Travel through the Pyramids; At the Pyramidal Decussation: 85% of fibers cross over to the contralateral side and continue descending in the Lateral Funiculus of the spinal cord as the Lateral Corticospinal Tract (LCST) while 15% of fibers remain ipsilateral, forming the Anterior Corticospinal Tract (ACST).

Termination and Function: LCST fibers progressively leave the tract to synapse on Interneurons in the Anterior Gray Horn, Some fibers synapse directly on Alpha and Gamma Motor Neurons, enabling precise voluntary motor control.

Anterior Corticospinal Tract (ACST): The uncrossed (ipsilateral) fibers continue descending in the Anterior White Column, They may cross at the spinal cord level before synapsing with Interneurons or Lower Motor Neurons.



The image depicts a major motor pathway known as the corticospinal tract. This pathway originates in the motor cortex (Cerebral cortex), the area responsible for voluntary movement control. The motor cortex contains neurons that send signals to muscles via this tract. The corticospinal tract begins in the cerebral cortex and descends through various brain structures, including the corona radiata, internal capsule, and cerebral peduncle. It then reaches the medulla oblongata, where a significant portion of its fibers cross over in an area called the decussation of pyramids. This crossing means that nerve fibers controlling one side of the body cross over to the opposite side of the spinal cord. After decussation, the corticospinal tract divides into two main branches: Lateral corticospinal tract This branch descends through the lateral column of the spinal cord and is responsible for controlling fine movements in the limbs (hands and feet). This is the tract highlighted in the image and Anterior corticospinal tract This

branch descends through the anterior column of the spinal cord and is responsible for controlling trunk and spinal movements.Ultimately, the nerve fibers in both tracts reach alpha and gamma motor neurons in the spinal cord, which send signals to muscles to produce movement.

Lateral Corticospinal Tract (LCST)

Descent and Regional Influence: Extends throughout the full length of the spinal cord, enabling voluntary motor control of the entire body, Synapse distribution along the spinal cord: 55% in the Cervical Region Strong influence on upper limb movement and 20% in the Thoracic Region also 25% in the Lumbar and Sacral Regions.

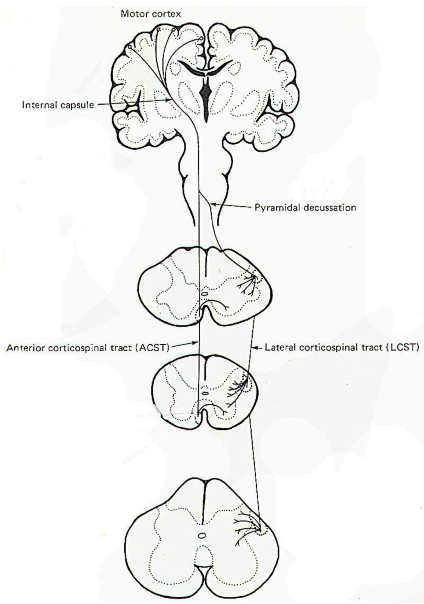
Synaptic Connections: LCST fibers synapse mainly on Alpha and Gamma Motor Neurons in the Anterior Horn, Most fibers connect via Interneurons in Laminae IV, V, VI, VII, VIII.

Exception Giant Cells of Betz: Around 3% of LCST fibers originate from Layer V of Area 4 (Primary Motor Cortex), These fibers synapse directly on lower motor neurons without interneurons, enabling precise and fine motor movements, especially in the fingers.

Anterior Corticospinal Tract (ACST)

Function and Influence:Primarily controls proximal muscles of the upper limb, especially the shoulder, Influences both the Ipsilateral and Contralateral sides.

Pathway of Fibers: Fibers exit the tract at various spinal levels and cross over in the Anterior White Commissure to synapse on Interneurons in the Anterior Gray Horn, This allows for coordinated movement and postural control.



The image shows a diagram of the corticospinal tract, the major pathway responsible for transmitting motor signals from the cerebral cortex to muscles. This tract is divided into two main branches:

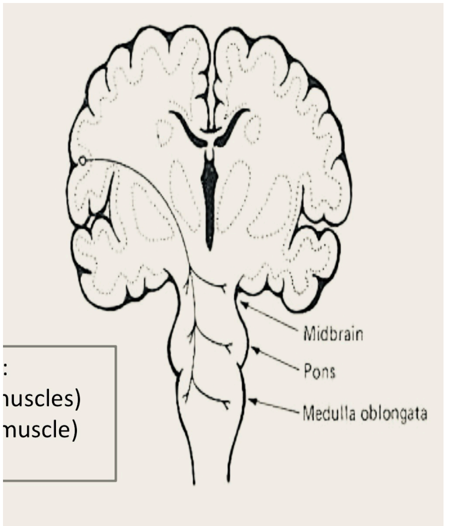
Lateral Corticospinal Tract (LCST): The diagram shows this tract descending from the motor cortex through the internal capsule to the medulla oblongata. At the medulla oblongata, pyramidal decussation occurs, where most fibers of this tract cross over to the opposite side of the spinal cord. This tract then descends through the lateral column of the spinal cord to influence the muscles of the limbs (hands and feet).

Anterior Corticospinal Tract (ACST): The diagram also shows this tract descending from the motor cortex, but it doesn't completely cross at the pyramidal decussation. Some of its fibers remain on the same side (ipsilateral) and some cross to the opposite side (contralateral) in the spinal cord via the anterior white commissure. This tract primarily influences the muscles of the trunk and proximal parts of the limbs (such as shoulder muscles). The accompanying text clarifies that this tract affects shoulder muscles on both sides (ipsilateral and contralateral).

Corticonuclear Tract (Corticobulbar Fibers)

Origin and Pathway: Composed of fibers originating from the lower quarter of the Precentral Gyrus (Motor Cortex), Descending fibers terminate in the motor nuclei of cranial nerves: Midbrain-CN III, IV; Pons-CN V, VI, VII and Medulla-CN IX, X, XI, XII.

Bilateral Input: Most Corticobulbar fibers provide Bilateral Input to brainstem motor nuclei; Exceptions: Lower facial muscles (CN VII - lower part) receive only Contralateral Input and Genioglossus muscle (CN XII - part of hypoglossal nerve) receives only Contralateral Input.



The image shows a diagram of the Corticobulbar Tract. This tract is a collection of nerve fibers originating from the lower part of the motor cortex in the brain (the area responsible for voluntary movements). The function of this tract is to transmit nerve signals from the cerebral cortex to the motor neurons in the brainstem that control the muscles of the head and neck.The diagram illustrates how fibers descend from the motor cortex to reach the various cranial nerve nuclei in the brainstem:

Midbrain: Cranial nerves III and IV.

Pons: Cranial nerves V, VI, and VII.

Medulla Oblongata: Cranial nerves IX, X, XI, and XII.

A key feature of this tract is that most of its input is bilateral, meaning that each side of the brain sends signals to both sides of the brainstem. However, there are two exceptions: The part of the seventh cranial nerve (VII) that innervates the lower facial muscles This part receives input from only one side of the brain and The part of the twelfth cranial nerve (XII) that innervates the genioglossus muscle This part also receives input from only one side of the brain.

Subconscious motor tracts are part of the Extrapyramidal System, which is responsible for involuntary motor control. These tracts regulate balance, posture, limb coordination, and automatic movements, Unlike pyramidal tracts (such as the corticospinal tract), which control voluntary, fine movements, subconscious motor tracts work automatically, transmitting

signals through multiple synapses, making them more complex; The subconscious motor system consists of four main tracts:

1- Vestibulospinal Tract

Function: Maintains balance and posture by controlling antigravity muscles (extensors in the legs), Stabilizes the head and eyes during body movement.

Pathway: Origin Vestibular nuclei in the brainstem, Course Descends in the anterior funiculus of the spinal cord, Termination Synapses with motor neurons in the anterior horn of the spinal cord.

Effect: Activates extensor muscles in the limbs to support posture and Inhibits flexor muscles to prevent unwanted movement.

Example:When a person loses balance, this tract automatically activates leg muscles to prevent falling.

2- Tectospinal Tract

Function: Controls head and eye movements in response to visual and auditory stimuli, Coordinates reflexive responses to sudden stimuli.

Pathway: Origin Superior colliculus of the midbrain (receives visual input), Course Crosses to the opposite side and descends in the anterior column of the spinal cord, Termination Synapses with motor neurons controlling neck and shoulder muscles.

Effect: Automatically turns the head and eyes toward a sudden sound or movement.

Example:When a person sees a fast-moving object, their head turns automatically toward it.

3- Reticulospinal Tract

Function: Regulates muscle tone and involuntary postural adjustments, Controls proximal limb movements for coordinated walking and balance, Facilitates automatic movements like walking.

Pathway: Origin Reticular formation in the brainstem, Course Divides into two pathways: Medial Reticulospinal Tract Excites extensor muscles for posture and Lateral Reticulospinal Tract Inhibits extensor muscles for smooth movement, Termination Synapses with motor neurons in the anterior horn.

Effect: Adjusts muscle tension automatically to maintain stability during movement.

Example:When walking on an uneven surface, this tract automatically adjusts muscle tone to prevent falling.

4- Rubrospinal Tract

Function: Controls fine motor movements of the upper limbs, Works with the corticospinal tract to refine movements.

Pathway: Origin Red nucleus in the midbrain , Course Crosses to the opposite side and descends in the lateral column of the spinal cord, Termination Synapses with motor neurons controlling flexor muscles in the upper limbs.

Effect: Helps regulate coordinated limb movements.

Example: When reaching for a small object, this tract fine-tunes hand and finger movements.

Comparison: Pyramidal vs. Extrapyramidal Tracts

Feature	Pyramidal Tracts	Extrapyramidal Tracts
Control	Voluntary movements	Involuntary posture & balance
Neural Pathway	Direct, few synapses	Indirect, multiple synapses
Muscle Control	Fine motor control	Gross motor coordination
Origin	Motor cortex (Area 4)	Brainstem

Conclusion: Subconscious motor tracts are essential for automatic movement regulation, helping to maintain balance, posture, and coordinated reflexes. They work continuously and involuntarily, ensuring smooth movement adjustments in daily activities like walking, head turning, and maintaining stability.

The rubrospinal tract is part of the extrapyramidal system, responsible for subconscious motor control. Its primary function is to facilitate flexor muscle activity and inhibit extensor muscles, especially in the upper limbs, aiding in coordinated movement, Neural Pathway of the Rubrospinal Tract

1- Origin: Arises from the Red Nucleus, which is located in the midbrain at the level of the superior colliculus; The red nucleus receives afferent fibers from: The cerebral cortex Particularly from the motor areas, allowing coordination between voluntary and involuntary movement and The cerebellum To assist in balance and movement coordination.

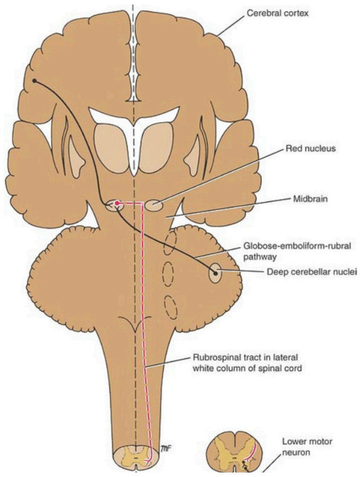
2- Decussation (Crossing Over): Fibers cross to the opposite side at the level of the red nucleus, meaning that the right rubrospinal tract controls the left side of the body and vice versa.

3- Pathway in the Spinal Cord: Descends in the lateral white column of the spinal cord, very close to the lateral corticospinal tract, making it part of the lateral motor system, Synapses with alpha and gamma motor neurons through interneurons in the anterior horn of the spinal cord.

Function: Excites flexor muscles and inhibits extensor muscles, Primarily affects distal flexor muscles (e.g., fingers and hands), with less effect on proximal muscles and Works alongside the corticospinal tract to provide fine motor control of the upper limbs.

Significance of the Rubrospinal Tract: In humans, its role is less dominant compared to the corticospinal tract, but it still contributes to motor control while In some animals, like primates, the rubrospinal tract is more developed and plays a major role in fine motor coordination.

The image depicts an important neural pathway known as the rubrospinal tract. This pathway originates in the red nucleus, located in the midbrain. The red nucleus is a small, reddish structure that plays a crucial role in controlling voluntary movement, particularly fine movements of the limbs, From the red nucleus, nerve fibers extend to form the rubrospinal tract, which descends through the spinal cord in the lateral white column. This tract connects with lower motor neurons, which are the neurons responsible for moving muscles.The diagram also shows the globose-emboliform-rubral pathway, a pathway connecting the deep cerebellar nuclei and the red nucleus. This pathway contributes to the coordination and modulation of movement. In summary, the diagram represents a crucial neural pathway for motor control, where the red nucleus relays signals from the cerebellum to the spinal cord to control muscle movements.



The diagram illustrates the rubrospinal tract, an important motor pathway originating in the red nucleus located in the midbrain. The red nucleus is characterized by its reddish color and plays a key role in controlling voluntary movements, particularly fine movements of the limbs.From the red nucleus, nerve fibers descend through the pons and medulla, reaching the spinal cord. In the spinal cord, the fibers pass through the lateral white column, where they synapse with lower motor neurons in the anterior horns. These lower motor neurons are responsible for muscle movement.The diagram shows that the nerve fibers cross (decussate) at the decussation, meaning that the red nucleus in one hemisphere of the brain controls movements of the opposite side of the body. This crossing allows for coordinated movement between both sides of the body.In summary, the diagram represents a crucial neural pathway for motor control, where the red nucleus relays signals from the midbrain to the spinal cord to control muscle movements, especially fine movements.

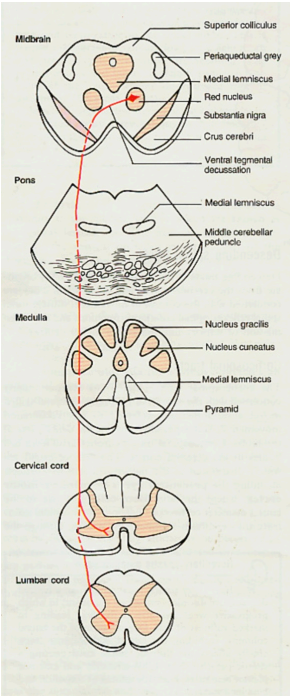


Fig. 5.17 Rubrospinal tract.

The reticulospinal tracts are part of the extrapyramidal system, playing a crucial role in muscle tone regulation, posture control, and coordination of automatic movements.There are two main reticulospinal tracts: Pontine Reticulospinal Tract and Medullary Reticulospinal Tract.

1- Pontine Reticulospinal Tract

Neural Pathway: Origin Reticular Formation of the Pons, Pathway Fibers descend uncrossed (Ipsilateral) through the Anterior White Column of the spinal cord, Also known as the Medial Reticulospinal Tract (MRST).

Activity: Tonically Active (continuously active), Normally inhibited by the cerebral cortex to prevent excessive muscle tone.

Function:Activates extensor muscles in the trunk and proximal limbs, helping maintain balance and posture.

2- Medullary Reticulospinal Tract

Neural Pathway: Origin Reticular Formation of the Medulla Oblongata, Pathway Fibers descend crossed and uncrossed through the Lateral White Column of the spinal cord, Also known as the Lateral Reticulospinal Tract (LRST).

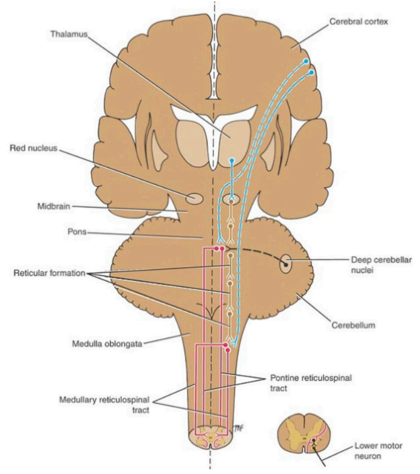
Activity: NOT tonically active, Normally stimulated by the cerebral cortex.

Function:Inhibits extensor muscles in the trunk and proximal limbs, allowing for controlled and adaptive movement.

Comparison Between Both Tracts

Feature	Pontine Reticulospinal Tract	Medullary Reticulospinal Tract
Origin	Pons	Medulla Oblongata
Spinal Cord Pathway	Anterior White Column	Lateral White Column
Crossing of Fibers	Uncrossed	Crossed & Uncrossed
Activity	Tonically Active	NOT Tonically Active
Cortical Influence	Inhibition	Stimulation
Function	Activates Extensors	Inhibits Extensors

The image shows two important neural pathways originating in the reticular formation, a complex network of neurons in the brainstem:



Pontine reticulospinal tract: This tract originates in the pontine part of the reticular formation (in the pons). Its fibers descend through the spinal cord in the anterior white column without

crossing. Its main function is to facilitate extensor muscles, contributing to posture and balance. This effect is known as its facilitatory effect on extensor muscles.

Medullary reticulospinal tract: This tract originates in the medullary part of the reticular formation (in the medulla oblongata). Its fibers descend through the spinal cord in the anterior white column, and partially cross. Its main function is to inhibit extensor muscles and facilitate flexor muscles, contributing to fine movements and flexibility. This effect is known as its inhibitory effect on extensor muscles.

In summary, these two tracts work together to regulate posture, movement, and balance, through their opposing effects on extensor and flexor muscles.”

The Vestibulospinal Tract is part of the subconscious motor pathways in the extrapyramidal system. It plays a crucial role in maintaining balance and posture by influencing extensor and flexor muscles.

Neural Pathway: Origin The Vestibular Nuclei, located in the pons and medulla oblongata, beneath the floor of the 4th ventricle, Afferent Inputs to Vestibular Nuclei: Inner Ear (Vestibular Apparatus) Receives signals via the Vestibular Nerve (part of Cranial Nerve VIII â€“ Vestibulocochlear Nerve), allowing it to detect head position and movement and Cerebellum Sends input to fine-tune balance and muscle tone control.

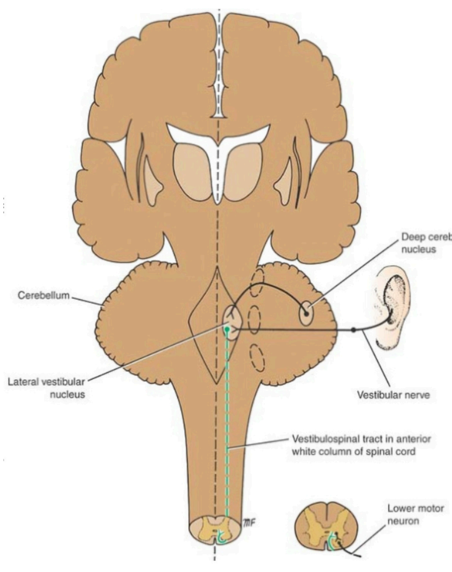
Pathway in the Spinal Cord:Uncrossed (Ipsilateral) fibers descend through the medulla oblongata, Travel through the anterior white column of the spinal cord, Synapse with motor neurons in the anterior gray column, influencing muscle control.

Function: Facilitates extensor muscles, promoting postural stability, Inhibits flexor muscles, preventing balance disruption.

Role in Balance Control: Plays a key role in postural reflexes, Adjusts body position during walking, standing, and sudden directional changes, Contributes to the Vestibulo-Ocular Reflex (VOR), stabilizing vision during head movements.

The Vestibulospinal Tract is essential for postural control and balance. By receiving sensory information from the inner ear and cerebellum, it regulates extensor and flexor muscles, ensuring stability and coordinated movement in daily activities.

The diagram illustrates the vestibulospinal tract, a neural pathway that transmits information from the vestibular system (located in the inner ear) to the spinal cord. Its primary function is to regulate balance and posture.The tract originates in the lateral vestibular nucleus, a group of neurons in the brainstem that receives information from the vestibular nerve, which carries signals from sensory receptors in the inner ear responsible for sensing balance and movement.From the lateral



vestibular nucleus, nerve fibers descend through the spinal cord in the anterior white column. These fibers do not significantly cross, meaning that signals from one side of the body primarily affect the same side.The vestibulospinal tract fibers synapse with lower motor neurons in the anterior horns of the spinal cord, leading to the activation of muscles necessary for maintaining balance and posture. It primarily affects the extensor muscles in the legs and back, helping to maintain an upright posture.In summary, the vestibulospinal tract is an important neural pathway for controlling balance and posture, transmitting information from the vestibular system to the muscles responsible for maintaining balance.

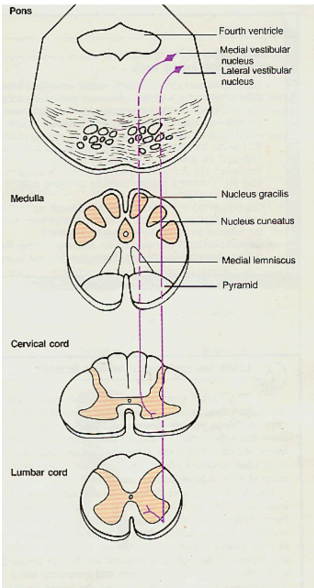


Fig. 5.19 Vestibulospinal tracts.

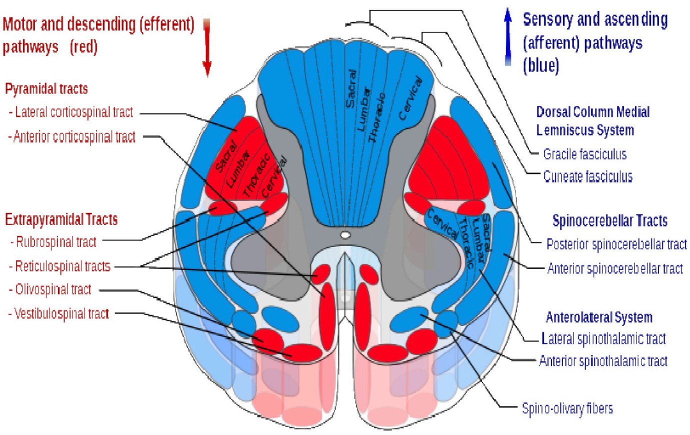
The image is a diagram illustrating the vestibulospinal tracts. These tracts explain how nerve signals travel from the vestibular system in the inner ear to the spinal cord, influencing balance and posture.The diagram begins in the brainstem, where the medial and lateral vestibular nuclei are located. Nerve fibers emerge from these nuclei and descend through the brainstem and spinal cord. The diagram shows these fibers passing through the cerebellum (though not detailed in the diagram) then branching into two main tracts:

Medial vestibulospinal tract: The diagram shows this tract terminating in the medial region of the spinal cord, particularly in the anterior columns. Its primary function is to control the muscles of the neck and back, helping to maintain head uprightness and stabilization during movement.

Lateral vestibulospinal tract: The diagram shows this tract terminating in the lateral region of the spinal cord, particularly in the anterior columns. Its primary function is to control the muscles of the limbs, helping to maintain balance and adjust body posture in response to sudden movements or changes in position.

The diagram also shows other structures in the brainstem and spinal cord, such as the gracile and cuneate nuclei, the medial lemniscus, and the pyramid. These structures have other functions not directly related to the vestibulospinal tracts, but they provide a broader anatomical context.

This image shows a cross-sectional view of the spinal cord, illustrating the motor (descending - red) and sensory (ascending - blue) pathways.



1. Motor and Descending Pathways (Red)

Pyramidal Tracts: Lateral Corticospinal

Tract, Anterior Corticospinal Tract.

Extrapyramidal Tracts: Rubrospinal Tract, Reticulospinal Tracts, Olivospinal Tract, Vestibulospinal Tract.

2. Sensory and Ascending Pathways (Blue)

Dorsal Column Medial Lemniscus System: Gracile Fasciculus Carries sensory information from the lower limbs and lower trunk and Cuneate Fasciculus Carries sensory information from the upper limbs and upper trunk.

Spinocerebellar Tracts: Posterior Spinocerebellar Tract, Anterior Spinocerebellar Tract

Anterolateral System: Lateral Spinothalamic Tract Responsible for transmitting pain and temperature sensations, Anterior Spinothalamic Tract Responsible for transmitting crude touch and pressure.

Spino-Olivary Fibers Transmit sensory information to the inferior olivary nucleus in the medulla, contributing to motor coordination.

Interpretation of the Image Based on Pathway Distribution:

1. Motor descending pathways (in red) are located in the anterior and lateral parts of the spinal cord, controlling voluntary and involuntary movements.

2. Sensory ascending pathways (in blue) are found in the posterior and lateral parts of the spinal cord, transmitting sensory input from the limbs and trunk to the brain.

3. Motor and sensory functions are integrated to ensure balance, movement, and precise perception of the body and its surroundings.

This image provides a detailed anatomical understanding of spinal cord pathways, which is essential in neuroscience, clinical anatomy, and neurological disorders.

The reticulospinal tracts are major motor pathways that play a crucial role in movement control, balance, and autonomic nervous system functions, These tracts also contain descending autonomic fibers, which serve as a pathway for the hypothalamus to regulate autonomic functions, These fibers allow the hypothalamus to control: Sympathetic outflow responsible for fight or flight responses; Parasympathetic outflow responsible for relaxation, digestion, and heart rate reduction; Most of these autonomic fibers originate from the lateral reticulospinal tract.

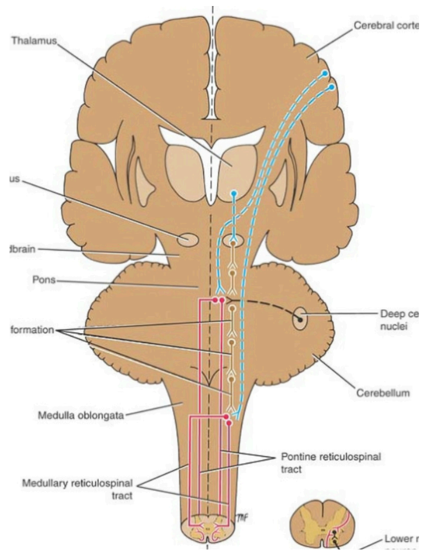
Primary Functions:

1. Motor Control: Influences voluntary and reflexive movements, especially in maintaining posture and locomotion.

2. Autonomic Regulation: Plays a significant role in modulating heart rate, respiration, and blood pressure.

3. Integration Between Brainstem and Spinal Cord: Connects higher centers (such as the hypothalamus) to the peripheral nervous system, ensuring coordinated motor and autonomic responses.

Importance of the Reticulospinal Tract:This pathway is essential for integrating motor control with autonomic functions, allowing the nervous system to maintain balance and respond appropriately to physiological demands.



The image shows a diagram of the reticulospinal tracts. These tracts are a collection of nerve fibers that originate from the reticular formation in the brainstem and descend to the spinal cord. The diagram shows two main tracts:

Pontine reticulospinal tract: This tract originates from the pontine part of the reticular formation. The diagram illustrates how its fibers descend to the spinal cord, where they excite lower motor neurons. Its primary function is to facilitate motor activity, increase muscle tone, and inhibit stretch reflexes. This tract helps maintain posture and standing.

Medullary reticulospinal tract: This tract originates from the medullary part of the reticular formation. The diagram illustrates how its fibers descend to the spinal cord, where they inhibit lower motor neurons. Its primary function is to inhibit motor activity, decrease muscle tone, and facilitate stretch reflexes. This tract helps regulate fine motor control and control involuntary movements.

The diagram also shows other connections of the reticular formation with other brain areas, such as the cerebellum, red nucleus, thalamus, and cerebral cortex. These connections demonstrate the role of the reticular formation in regulating many neural functions, including wakefulness, sleep, movement, and pain control.

The tectospinal tract is a descending motor pathway originating from the superior colliculus of the midbrain, playing a crucial role in reflexive head and neck movements in response to visual stimuli.

Anatomical Pathway:

1. Origin:Arises from nerve cells in the superior colliculus of the midbrain, a part of the visual system that processes retinal input.

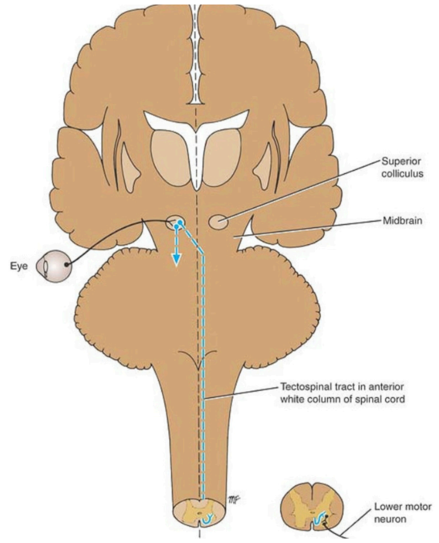
2. Decussation (Crossing): The fibers cross to the opposite side (contralateral pathway) at the midbrain level before descending.

3. Descending Path:The tract travels down through the anterior white column of the spinal cord, close to the anterior median fissure.

4. Termination:Most fibers terminate in the anterior gray column of the upper cervical spinal cord segments.

Function: Controls reflexive head and neck movements in response to visual stimuli, such as: Quickly turning the head toward a sudden light or moving object, Coordinating head and eye movements for tracking visual targets.

Significance:Plays a key role in defensive visual reflexes, allowing rapid orientation toward potential threats, Integrates visual information with neck muscle responses, ensuring smooth and adaptive head movements.



The image shows a diagram of the tectospinal tract. This tract is a relatively small neural pathway that conveys signals from the superior colliculus in the midbrain to the spinal cord.The diagram begins at the superior colliculus, a region in the midbrain that plays a key role in processing visual and auditory information related to movement. The superior colliculus receives input from the retina (as shown in the diagram) and other brain areas. When the superior colliculus detects visually or auditorily salient stimuli, it sends signals via the tectospinal tract.The diagram illustrates how the fibers of the tectospinal tract descend through the brainstem to the spinal cord, where they synapse with lower motor neurons in the anterior columns of the spinal cord. The primary function of the tectospinal tract is to coordinate rapid reflex movements of the head, neck, and trunk in response to sudden visual and auditory stimuli. For example, if an object suddenly appears in your visual field, the tectospinal tract will help to quickly turn your head toward that object.In short, the tectospinal tract is an important neural pathway in visual and auditory reflexes, allowing us to quickly respond to stimuli in our environment.

Motor pathways are classified into two main systems based on the type of muscles they control:

 # Medial Motor System: Controls axial (core) and proximal muscles, which are essential for posture, balance, and gross body movements.

Pathways in this system:

1. Anterior Corticospinal Tract: Controls axial muscles of the neck, trunk, and shoulders; Unlike the lateral corticospinal tract, most fibers do not cross in the medulla but instead cross at the spinal cord level through the anterior white commissure.

2. Extrapyramidal Pathways, Include several important tracts: Vestibulospinal Tract Facilitates extensor muscles and maintains balance, Tectospinal Tract Controls reflexive head

and neck movements in response to visual stimuli, Reticulospinal Tract Regulates muscle tone and posture.

 # Lateral Motor System: Controls distal muscles, allowing for fine motor control, particularly in the hands and fingers.

Pathways in this system:

1. Lateral Corticospinal Tract: Primarily responsible for voluntary movements of the limbs, 85% of its fibers decussate (cross) at the pyramidal decussation in the medulla, Fibers descend throughout the spinal cord, synapsing on lower motor neurons directly or via interneurons.

2. Rubrospinal Tract: Primarily controls proximal and distal flexor muscles, Originates in the red nucleus of the midbrain and crosses immediately, Works in conjunction with the lateral corticospinal tract for fine motor control, particularly in the upper limbs.

Functional Importance: Medial Motor System Responsible for posture, balance, and gross movements involving the trunk and proximal limbs and Lateral Motor System Facilitates precise voluntary movements, particularly for the hands and fingers.

Comparison Between Upper Motor Neuron (UMN) and Lower Motor Neuron (LMN) Lesions

1. Upper Motor Neuron (UMN) Lesions:

Pathway:Starts from the motor cortex and extends to the cranial nerve nuclei in the brainstem or anterior horn cells in the spinal cord.

Effects of Lesion: Muscle Bulk: No wasting, Muscle Tone: Increased (Hypertonia), Muscle Power: Spastic Paralysis, affecting groups of muscles, Reflexes: Exaggerated (Hyperreflexia), Clonus: Present, Babinski Sign: Positive (indicates UMN damage), Fasciculations: Absent.

COMPARISON BETWEEN UMN AND LMN

Features	Upper motor neuron lesions(UMN)	Lower motor neuron lesion(LMN)
	UMN starts from motor cortex to the cranial nerve nuclei in brain and anterior horn cells in spinal cord	LMN is the motor pathway from anterior horn cell(or Cranial nerve nucleus)via peripheral nerve to the motor end plate
Bulk of muscles	No wasting	Wasting of the affected muscles (atrophy)
Tone of muscles	Tone increases (Hypertonia)	Tone decreases (Hypotonia)
Power of muscles	Paralysis affects movements of group of muscles Spastic/ clasp knife	Individual muscles is paralyzed Flaccid (flaccid paralysis)
Reflexes	Exaggerated. (Hyperreflexia)	diminished or absent. (Hyporeflexia)
Fasciculation	Absent	Present
Babinski sign	Present	Absent
clasp-knife reaction	Present	Absent
Clonus	Present	Absent

hypertonia and hyperreflexia, is the result of an increase in gamma motor neurons activity

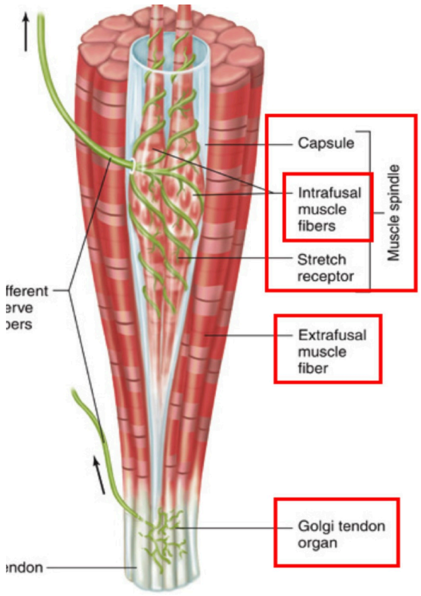
2. Lower Motor Neuron (LMN) Lesions:

Pathway:Starts from anterior horn cells or cranial nerve nuclei and extends via peripheral nerves to the motor end plate.

Effects of Lesion: Muscle Bulk: Wasting (Atrophy), Muscle Tone: Decreased (Hypotonia), Muscle Power: Flaccid Paralysis, affecting individual muscles, Reflexes: Diminished or absent (Hyporeflexia), Clonus: Absent, Babinski Sign: Negative, Fasciculations: Present.

Key Clinical Importance: UMN lesions result in spastic paralysis due to increased gamma motor neuron activity while LMN lesions cause flaccid paralysis due to direct loss of motor innervation, leading to muscle atrophy.

What Are Muscle Spindles? Muscle spindles are sensory receptors located within the belly of a muscle. Their primary function is to detect changes in muscle length and send feedback to the nervous system to regulate movement and posture.

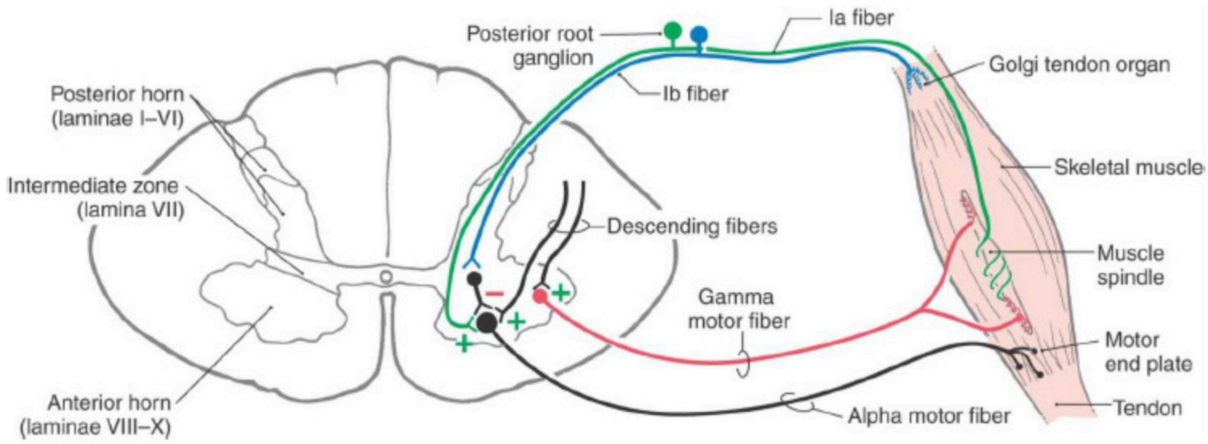


Structure and Composition: Each muscle spindle consists of a capsulated cluster of specialized muscle fibers called intrafusal muscle fibers, These fibers have an unusual structure, where the nuclei are concentrated near the middle of the fiber, forming nuclear bag fibers or nuclear chain fibers.

Types of Muscle Fibers in Skeletal Muscle:

1. Extrafusal Fibers (99%): Make up the majority of the muscle, Responsible for force generation and movement, Innervated by alpha motor neurons.

2. Intrafusal Fibers (1%): Only a small portion of the muscle fibers, Do not contribute to force production but instead sense muscle stretch, Innervated by gamma motor neurons, Depend on muscle spindle receptors to send sensory feedback to the central nervous system.



Activating Alpha Motor Neurons:

Directly through supraspinal centers (Descending motor pathways - UMN): These pathways include neurons that start in the brain and travel to the spinal cord, directly influencing the alpha motor neurons.

Indirectly through Muscle Spindles: Muscle spindles are internal sensors in muscles that monitor stretching and contraction. They help regulate muscle movement by stimulating motor neurons.

Stretch Reflex:This occurs when skeletal muscles are shorter than the distance between their origin and insertion. In this case, the stretch reflex helps maintain muscle balance and provides quick responses.

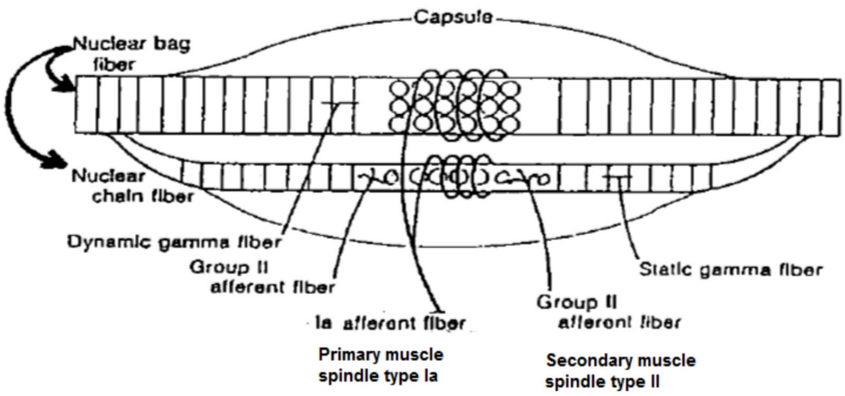
Gamma Loop:This is an integrated process involving both alpha and gamma motor neurons, where these circuits interact to regulate muscle tone and fine-tuned movements.

Differences between Alpha and Gamma Fibers: Gamma fibers activate muscle fibers indirectly, while alpha fibers do it directly and Alpha fibers provide faster but shorter contractions while Gamma fibers provide slower but longer contractions.

Applications of Stimulation: For fast contraction-Stimulate alpha fibers, For muscle tone-Stimulate gamma fibers, For continuous contraction and precise movement-Stimulate both alpha and gamma fibers together.

Intrafusal Fibers:

Nuclear Bag Fibers:These fibers are supplied by dynamic gamma fibers, which are responsible for detecting rapid changes in muscle length, aiding in quick responses.



Nuclear Chain Fibers:These fibers are supplied by static gamma fibers, which are responsible for detecting slower changes in muscle length, helping in long-term muscle tone regulation.

Key Notes on Nuclear Fibers:Both nuclear bag and chain fibers do not contain sarcomeres, which are the structural units responsible for muscle contraction.

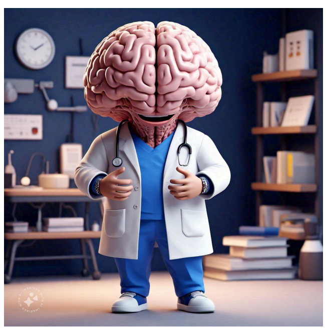
Primary Afferent (Type Ia):These are found around both nuclear bag and chain fibers and adapt rapidly to changes in muscle length.

Dynamic Stretch Reflex: Examples include the knee-jerk or ankle-jerk reflex (such as the quick response of the quadriceps muscle).

Secondary Afferent (Type II): These are only found in nuclear chain fibers and adapt slowly to changes in muscle length.

Static Stretch Reflex: This is important for maintaining muscle tone over the long term.

ملاحظة هامة: تم تكرار شرح بعض المواضيع أكثر من مرة على مختلف الصور، وذلك تسهيلاً لحفظ الموضوع أثناء الدراسة وضرورة تكرار الموضوع وقراءته لأكثر من مرة.



Good luck.

My passion for neuroscience and the brain is an unending drive, a dream that fills my heart and determination to be the first to uncover the mysteries of the human mind and contribute to its healing with all the knowledge and perseverance I have.

I swear by Allah the Almighty that I will become the number one doctor in neurosurgery and brain surgery in the world, regardless of who approves or disapproves, with God will, and I will give everything I have to achieve this noble .